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Instituições políticas e desenvolvimento econômico: uma análise espacial local para o Brazil

Political institutions and economic development: a local spatial analysis for Brazil

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RIBEIRÃO PRETO
2020

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Dissertação apresentada ao Programa de Pós-Graduação em Economia – Área: Economia Aplicada da Faculdade de Economia, Administração e Contabilidade de Ribeirão Preto da Universidade de São Paulo, para obtenção do título de Mestre em Ciências. Versão Original.

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"All models are wrong, but some are useful."
- George Box

RESUMO

SUZUKI, W. Y. N. **Instituições políticas e desenvolvimento econômico: uma análise espacial local para o Brazil.** Dissertação (Mestrado) – Faculdade de Economia, Administraçãoe Contabilidade de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto, 2020.

Instituições políticas, caracterizadas por North and Thomas (1973) e Acemoglu et al. (2001), são um componente importante para explicar desenvolvimento econômico. O objetivo deste trabalho é o de mensurar a heterogeneidade espacial da relação entre instituições políticas e desenvolvimento. Para isso é utilizado o método de janela espacial móvel aplicada a regressões com pesos, chamado de *Geographically Weighted Regression* (GWR), proposto em Fotheringham et al. (2002). Em econometria espacial e análises estatísticas globais, é comum assumir um DGP (*Data Generating Process*) homogêneo para todo mapa ou amostra. Por outro lado, a vantangem de análises estatísticas locais é que é possível estimar o DGP não estacionário que subsiste no mapa. De forma geral, é concluido que institutições políticas têm um impacto positivo no desenvolvimento econômico. Mas análises estatísticas locais mostram que para muitas partes do Brasil o efeito é nulo ou negativo. São apresentados mapas indicando onde a relação é positiva, negativa e não significativa. A análise é feita com uma base de dados *cross-section* espacial dos municípios do Brasil para o ano de 2000.

Palavras-chave: Instituições Políticas. Desenvolvimento Econômico. Estatística Espacial Local.

ABSTRACT

SUZUKI, W. Y. N. **Political institutions and economic development: a local spatial analysis for Brazil.** Dissertation (Master Degree) – School of Economics, Business and Accounting at Ribeirão Preto, University of São Paulo, Ribeirão Preto, 2020.

Political institutions, characterized by North and Thomas (1973) and Acemoglu et al. (2001), are an essential component to explain economic development. The objective of this study is to measure the spatial heterogeneity of the relationship between political institutions and development. For this, we use a spatial moving window method applied to weighted regressions, called Geographically Weighted Regression (GWR), proposed in Fotheringham et al. (2002). In spatial econometrics and global statistical analysis, the common assumption is that the DGP (Data Generating Process) is homogeneous for the whole map or sample. On the other hand, the advantage of the *local* statistical analysis is that we can estimate the spatially non-stationary DGP underlying the map. Overall we find evidence that political institutions increase economic development. However, local statistical analysis shows that for many parts of Brazil the effect is null or even negative. We present maps indicating where the relationship is positive, negative, and non-significant. The dataset is a spatial cross-section on the municipalities of Brazil for the year 2000.

Keywords: Political Institutions. Economic Development. Local Spatial Statistics.

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1 Introduction

North (1990) defines institutions as the rules of the game. They are the mechanisms developed by society to constrain the choices of individuals. Good institutions are characterized by adequate private property protection, low levels of distortionary policies, more distribution of political power, and political and economic stability (Acemoglu et al., 2001). The argument is that people and agents living in places with better property rights and less distortionary policies will have more incentives to invest in human and physical capital and promote technological change.

The literature of institutions and economic performance has focused on cross-country analysis with aggregate data. The institutional literature of economic growth with aggregate data has been largely studied already (Johnson and Papageorgiou, 2018). The cross-country studies clearly show that, at the international level, institutions are crucial to explaining economic performance. Pande and Udry (2005) propose that studies trying to explore this relationship should focus on i) intra-country data, ii) on policies that change the institutional environment, and how these changes affect economic performance.

Following Acemoglu and Robinson (2012), there are *inclusive* and *extractive* institutions. Also they make the division between *political* and *economic* institutions. Inclusive political institutions are more democratic, have more civic engagement, less corruption, and more political equality. Economic inclusive institutions are related to better property rights and protection against expropriation by the government. The shortage of democratic representation and lack of incentives to invest are some examples of extractive institutions. They are called extractive because they were designed to extract resources from society to benefit a few from the elite.

The quality of institutions is one of the leading causes of economic development, but the reverse causality is usually an issue, i.e., those municipalities with high income can afford to build good institutions. To control for the endogeneity problem, we apply 2SLS using geographical and historical variables as instruments.

We use the proximity of the municipalities from the Sugar and Gold Cycles instrument and the distance from Portugal as instruments following Naritomi et al. (2012). In the case of sugar and gold economic cycles in Brazil, the Portuguese and the elite of Brazil were using the colonial economic activities to extract wealth to send to the Metropole. Therefore, the institutions associated with the colonial economic activities are highly extractive, and the proximity with the two cycles is related to worse institutional quality. Those regions of the country closer to Portugal had a stronger influence of the Metropole and, as a consequence, were those in which extractive institutions were historically established with higher intensity. Therefore, the hypothesis is that geography and historical events affect income through institutions.

The objective of this study is to analyze the impact of political institutions on economic development in Brazil. We use municipal level data for Brazil and local spatial statistics, in particular, Geographically Weighted Regression (GWR) to measure this relationship locally. One of the advantages of analyzing a dataset within a country scenario is that most of the *de jure* institutions are the same. Hence the analysis will capture differences in the *de facto* municipal institutional aspects, which is related to the informal institutions. Brazil had a single colonizer and shares a single language. It is centralized in the federal sphere. But within a constant *de jure* scenario, the different regions of the country can have heterogeneous *de facto* institutional set leading to a distinct degree of economic and political concentration of power that can have an impact on economic development and welfare.

Besides this introduction, the next section brings a literature review of the importance of institutions on economic development. Section three explains the methodology and the instrumentalization procedure. Section four reports the dataset and its source, the summary statistics, and the maps' distribution of the main variables. In section five, we present the empirical results and discuss them.

One of the main contributions of the present paper is to use local spatial statistics as the estimation method. The usual approach is the *global statistical analysis* method, which considers that the whole DGP is stationary. The global statistical analysis method regards that differences in local statistics are due to either sampling variation or wrong specification (Fotheringham et al., 2002, p. 10). Hence, our approach is considerably different from previous studies tackling the relationship between institutions and development in Brazil.

The human development index, education, economic inequality, and GDP per capita are all variables that we use to represent economic development. The IDHM is an adapted index from the methodology of countries HDI.

2 Literature and Institutional Theory

The following passage from Hall and Jones (1999) neatly defines the notion of institutions, which they call social infrastructure, and the causality relationship between institutions and economic development.

> "By social infrastructure, we mean the institutions and government policies that determine the economic environment within which individuals accumulate skills, and firms accumulate capital and produce output. A social infrastructure favorable to high levels of output per worker provides an environment that supports productive activities and encourages capital accumulation, skill acquisition, invention, and technology transfer. Such a social infrastructure gets the prices right so that, in the language of North and Thomas (1973), individuals capture the social returns to their actions as private returns." (Hall and Jones, 1999, p. 84)

Most of the empirical literature focused on the relationship between economic performance and institutions use cross-country data. (Hall and Jones, 1999; Mauro, 1995; Knack and Keefer, 1995) In a survey, Pande and Udry (2005) argue that cross-country studies are basically "complete". The authors propose a research agenda that focuses on micro-level data directed to two main themes: i) the relationship between income and institutions on the regional level; ii) and how the same institutional framework affects distinct social classes. The focus of the present study is on item i).

North and Thomas (1973) in their book, "The Rise of the Western World", explain the causes of economic prosperity of nations as a consequence of their social infrastructure, specifically a certain set of institutions that are essential for economic prosperity:

> "Our arguments central to this book are straightforward. Efficient economic organization is the key to growth; ... Efficient organization entails the establishment of institutional arrangements and property rights that create an incentive to channel individual economic effort into activities that bring the private rate of return close to the social rate of return." (North and Thomas, 1973, p. 1)

One of the most important forms to bring "the private rate of return close to the social rate of return" is through "justice and the enforcement of property rights", which are public goods promoted by the State. Political institutions are crucial in this aspect since they are key to the determination of economic institutions that promote economic prosperity. The most important example of inclusive economic institutions is the protection of property rights (North and Thomas, 1973, p. 7).

Sokoloff and Engerman (2000) have studied the divergence in economic prosperity in the Americas. They point that in the 17th and 18th centuries, the different regions of the continent were similar in income per capita, but at the beginning of the 19th century, North American countries started to grow and modernize very rapidly leaving the Latin American countries behind. They argue that North America and Latin America were different in political and economic equality since their formation, and, they conclude that:

> "These early differences in the extent of inequality across New World economies may have been preserved by the types of economic institutions that evolved and by the effects of those institutions on how broadly access to economic opportunities were shared. This path of institutional development may in turn have affected growth. Where there was extreme inequality, and institutions advantaged elites and limited the access of much of the population to economic opportunities, members of elites were better able to maintain their elite status over time ... such [differences] ... in the paths of institutional development likely go far in explaining the persistence of inequality over the long run in Latin America and elsewhere in the New World." (Sokoloff and Engerman, 2000, p. 228)

Putnam (1993) in his book about changes in the political institutions of Italian regions in the 1980s, finds evidence of how political institutions impact on the economy and welfare. He argues that the institutional differences found between the northern and southern Italian regions can be historically traced back since the 12th century, in the south, the Kingdoms of Sicily and Naples were strengthened with the arrival of the Norman mercenaries which helped to secure and promote "the monarchy assertion of a monopoly over the provision of justice and public order" and endorse "the privileges of the feudal nobility" in a system much like the rest of Feudal Europe. But in the northern and central Italy, with the establishment of communal republics, like Venice and Florence, "an unprecedented form of self-government was emerging" the main difference in the north is a political system "fundamentally more liberal and egalitarian than in contemporary regimes".

It is clear that institutions affect economic performance, but it is likely that rich economies are those that can support good quality institutions as claimed by the modernization theory. Therefore we have a potential endogeneity problem. Modernization theory asserts that institutional change happens due to economic progress, which is the argument that motivates the simultaneity problem tackled by many empirical studies. On the other hand, Acemoglu and Robinson (2012) argue that what causes economic growth is an increase in institutional quality. They argue that economic progress built in extractive political institutions is what sustains the power of the elite running the system, which is in opposition to modernization theory, and in line with Sokoloff and Engerman (2000) about how the elites can, in some circumstances, hinder development.

The modernization hypothesis argues that economic prosperity will lead to more inclusive institutions through increasing demand for democracy and participation in political and economic decisions. But Acemoglu and Robinson (2012) assert that economic

and political institutions are determined by political events, and in some cases, random historical events. The concentration of power creates extractive political institutions.

The idea of positive interaction between economic and political institutions are also in Acemoglu et al. (2005), in which inclusive political institutions promote economic prosperity through the broadening of political power. This economic prosperity, in turn, reinforces the system with inclusive political institutions.

Acemoglu et al. (2001) uses data on colonial settler's mortality as an instrumental variable to control for the endogeneity problem. European settlers did not settle in places where the climate was not adequate for them to live. But usually, locations where diseases were common, were also appropriate for producing and extracting valuable resources to export. Hence in locations with high mortality rates, European settlers were more propense to establish extractive institutions. In locations in the New World where the climate was less appropriate for the development of tropical diseases, they established settlement colonies, which were generally characterized by inclusive institutions.

With municipal level data in Brazil, the results of Nakabashi et al. (2013) point to the relevance of institutions in promoting economic development. Niquito et al. (2018) compared the relative importance of human capital and institutions on municipal income. Based on cross-sectional data, both studies found evidence that institutional quality has a significant impact on economic development. Also, the study of Niquito et al. (2018) indicates that institutions are more important to determine municipal income level than human capital. The theoretical explanation is that an adequate institutional environment is essential to encourage individuals and firms to invest in human and physical capital. These results are in line with North and Thomas (1973)'s theoretical framework in which they propose that the proximate factors of economic development (human and physical capitals and technology) are determined by institutional quality, which is the fundamental cause of development.

Niquito et al. (2018) uses the proportion of blacks and pardos in the municipalities of Brazil in 1872 as an instrument for institutional quality. The authors argue that the regions with more blacks and pardos were those in which the Portuguese established the institutions of slavery and colonial exploitation. Hence those are the regions with low institutional quality. Nakabashi et al. (2013) use geographical and historical variables as instruments for institutions. They argue that the Brazilian regions with warmer climates and closer to the equator were those that experienced extractive institutions.

Naritomi et al. (2012) propose instruments that mark the presence of the colonial economic cycles of sugar and gold in Brazil. They show evidence that the presence of those cycles influence economic and welfare outcomes until nowadays:

> "Specifically, municipalities with origins linked to the socially polarized and oligarchic economy of the sugar cane episode are characterized by higher concentration of land. ... Municipalities with origins associated with the gold episode have today worse governance practices and less access to justice. ... In both the sugar cane and gold episodes, the negative consequences are significantly worse when the municipalities are closer to Portugal, highlighting the negative influence of the interference of the Metropole, particularly when associated with extractive activities." (Naritomi et al., 2012)

Brazilian colonial history was marked by economic cycles of specific periods, products, and locations. Between the 16th and 17th centuries, the main product was sugar that was exported to Europe, and its production concentrated on the coast of the Northeast region.

Between the 17th and 18th centuries, the main product was gold and diamonds extracted in the state of Minas Gerais, and in some places of the Center-West and Northeast of the country. (Naritomi et al., 2012)

The sugar cane colonial cycle was characterized by an oligarchic society, where a few Portuguese "sugar mill lords" ruled over a mass of slaves. This inequality of power was marked by the presence of the "latifúndio", which is a large landed estate with a Portuguese lord overseeing it and monoculture. Colonies of exploitation were mainly designed with extractive institutions. The Portuguese started to occupy the Northeast of Brazil in the Sugar cycle, given the favorable climate for the crop and the proximity to the Metropole. Then later, the central portion of Brazil was occupied in the Gold cycle. When the stock of minerals or fertility of the land started to dwindle, they sought another extractive economic opportunity. Naritomi et al. (2012) assert that the relatively small quantity of woman and basic types of daily goods and supplies points to, the extractive nature of the Colonial enterprise. Likewise, Dell (2010) shows that the presence of the extractive institution of Mita established during the Spanish colonial period in Peru and Bolivia has still impacted today's economic and social measures.

3 Methodology

In the econometric analysis of the relationship between institutional quality and economic development, the main issue is simultaneity. Hence, we cannot find unbiased estimators unless we use instrumental variables. In this section we explain our instrument, and the methods for estimating this relationship, assuming a non-stationary process.

In the theoretical framework of North and Thomas (1973), the authors explain that there are two causes for development: fundamental ones; and the proximate ones. The institutional framework, geographic, and cultural variables are pointed out as fundamental causes. Technological progress, human and physical capital accumulation are considered as proximate causes. The causal reasoning of North and Thomas (1973) is that the institutional framework is the cause of physical and human capital accumulation and technological progress, and these promote economic development, as in the following scheme:

$$\text{institutions} \Longrightarrow \begin{array}{c}\text{human capital}\\ \text{physical capital}\\ \text{technology}\end{array} \Longrightarrow \text{economic performance}$$

Within this kind of causal framework, Angrist and Pischke (2009) argue that it is inappropriate to use, for example, human capital and institutions as controls at the same time to explain economic development. Because institutional quality affects human capital accumulation, and the latter is crucial on the the economic development process, it is meaningless to assess the effects of institutions on economic development holding human capital constant, making it difficult to interpret the estimated coefficients. Therefore, we examine the relationship between welfare and political institutions, without including human or physical capital as covariates.

> Some variables are bad controls and should not be included in a regression model even when their inclusion might be expected to change the short regression coefficients. Bad controls are variables that are themselves outcome variables ... That is, bad

controls might just as well be dependent variables too. (Angrist and Pischke, 2009, p. 48)

Figure 1 shows the borders of municipalities. Note that the municipalities' area changes drastically across the Brazillian regions. In the North and Center-West of the country, municipalities generally have a bigger area in relation to the rest of the country. The North and Center-West of the country are also less populated.

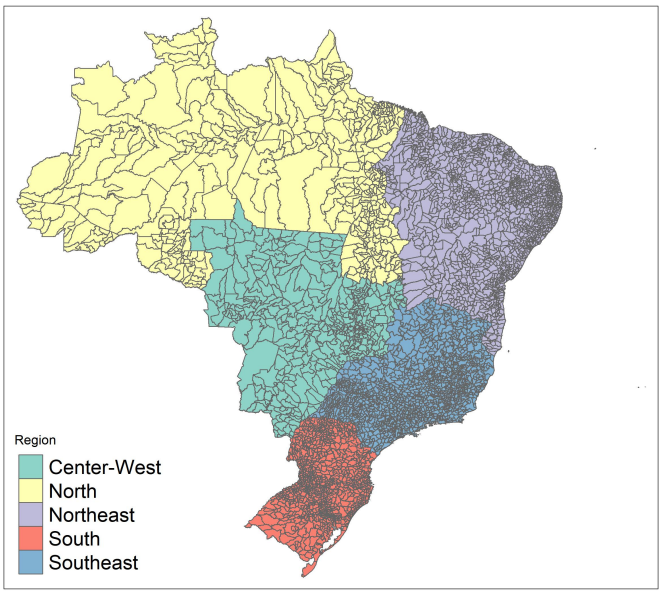


Figure 1: Borders of municipalities and regions

3.1 Gold and Sugar Cycles and the Metropole

We use the variables constructed by Naritomi et al. (2012) as instruments. The instruments are the municipalities distance from the gold or sugar cycles, and their distance from Portugal.

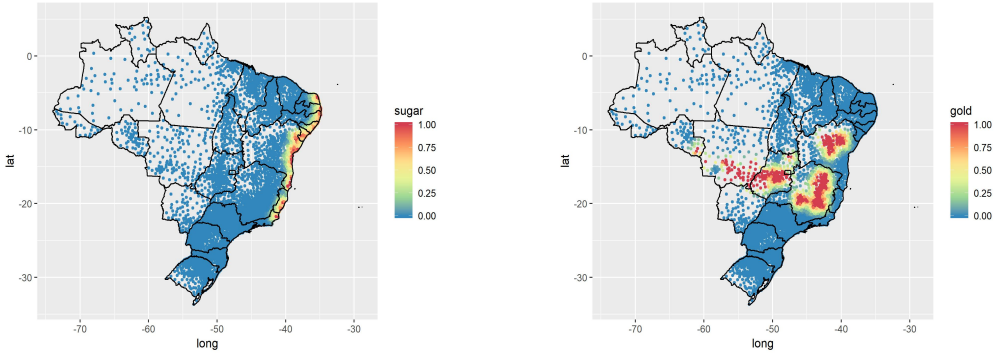
Figure 2 highlights the municipalities where the two cycles took place or that were close to them. Each point is the centroid of a municipality. Naritomi et al. (2012) use a linear kernel of 200km, as in Equation (1), to construct the instrument based on the two cycles.

$$W_i = \begin{cases} \left(\frac{200 - d_i}{200}\right)^2 & \text{if } d_i \leq 200 \text{ km} \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

If one of the two cycles took place in a municipality, it received a value of 1. If a municipality was not directly influenced by them, then equation (1) was used to attribute a weight for the influence of the cycles.

Note that around the red points the intensity of gold and sugar cycles decreases.

Figure 2: Sugar and Gold



(a) Sugar (b) Gold

We argue that the influence of the gold and sugar cycles and the distance from Portugal are better instruments than the geographic variables used in the literature. The former instruments have better support from institutional theory and are more related to Brazilian history.

Distance from Portugal and the influence of the cycles are all related to the Brazilian history and geography, and they are exogenous features concerning the current economic development level.

One could argue that distance to coast or proximity and ease of trade with the metropole actually are positive for economic development. But as Naritomi et al. (2012) show this is dominated by the negative effect of the institutional framework established by the Portuguese.

These instruments had a decisive influence in the institutions of the past, which in turn determine contemporaneous institutions, given that the institutional frameworks are persistent through time. And finally current institutional set determines economic development. The causal reasoning is the following:

Geography and History $\rightarrow$ past institutions $\rightarrow$ institutions today $\rightarrow$ economic development

The first stage of the 2-Stage Least Squares Method (2SLS) is:

$$\text{inst} = \alpha_0 + \alpha_1 \text{gold} + \alpha_2 \text{sugar} + \alpha_3 \text{dist} + \alpha_4 \text{dist} \cdot \text{gold} + \alpha_5 \text{dist} \cdot \text{sugar} + \eta \quad (2)$$

This specification is proposed by Naritomi et al. (2012). Table 3 report other specifications, but we use the predicted value of the municipal institutional quality via Equation (2).

Henceforth, we call *instrumentalized institutions* as the fitted values for "inst" from Equation (2), and we refer to *original institutions* as the original variable for IQIM, that is, not instrumentalized. We use the instrumentalized institutions as a covariate to explain economic development since, after the first stage, the variable that measures institutional quality is not correlated with the error term through simultaneity.

In Equation 2, "dist" is distance from Portugal. We include the instruments and the cross effect of the distance from Portugal with the Gold and Sugar cycles. With this specification, we expect that the influence of the gold and sugar cycles decrease

institutional quality. Hence, we expect $\alpha_1, \alpha_2 < 0$. We expect that municipalities distant from Portugal have better institutions because they were harder to be controlled by the Metropole, and therefore, it was more difficult to implement colonial extractive institutions on then, so we expect $\alpha_3 > 0$. We also expect that municipalities with the influence of the gold or sugar cycles will have a better institutional set, as they are more distant from Portugal since the colonial extractive institutions would be less intense. Hence, we expect that $\alpha_4, \alpha_5 > 0$ (Naritomi et al., 2012).

One of the main contributions of the present paper is to use local spatial statistics as the estimation method. However, in the first stage of the Instrumental Variable (IV) method, we employ the global regression estimation. Hence, we adopt the assumption that the Data Generating Process (DGP) in which geographic and historical characteristics determine institutions is stationary in the whole country.

A single global regression compares places with and without colonial institutions of gold and sugar, also it can capture the differences in distance to Portugal. Those are meaningful comparisons, in a theoretic and historical sense. If we do local regressions in the first stage in many instances we cannot capture the effects of sugar and gold colonial institutions, or even capture the effect of distance to Portugal.

3.2 Geographically Weighted Regression

We assume that the underlying DGP of our sample is non-stationary and that the DGP changes in a smooth way. For the estimations, we use the *local statistical analysis* method.

The usual approach is the *global statistical analysis* method, which considers that the whole DGP is stationary. The global statistical analysis method regards that differences in local statistics are due to either sampling variation or wrong specification (Fotheringham et al., 2002, p. 10).

We consider the DGP as:

$$\text{devl}_j = \beta_{0j} + \beta_{1j}\text{inst}_j + u_j \tag{3}$$

Where "devl" means economic development and "inst" is the institutional quality. Each municipality j has different parameters β_{0j}, β_{1j}, but we assume that closer municipalities have similar parameters. We assume that there are no discontinuous breaks in the DGP. This assumption is in line with the *first law of geography*: "everything is related to everything else, but near things are more related than distant things" (Tobler, 1979).

Equation 3 is a simple linear relationship, in line with Hall and Jones (1999) in which our specification reflects the "belief that institutions are the fundamental determinant of economic development."

Steps in Geographically Weighted Regression Here, we explain the steps in the geographically weighted regression: 1. The first step is to select a municipality; for example, the municipality of São Paulo; 2. Then we use a kernel function (e.g. exponential) to give weights to each municipality according to distance from São Paulo; 3. With these weights, we run the econometric model, in the case of GWR a weighted least squares; 4. Then we associate the obtained estimates (e.g.: $\hat{\beta}_{1j}$, t-statistics) with São Paulo; 5. We repeat this process with all the 5502 municipalities; Note that for each municipality j we need to find a different weighting vector.

We have estimated different $\hat{\beta}_{1j}$ for each municipality. To visualize this result, we plot a map showing each municipality's $\hat{\beta}_{1j}$, sd$[\hat{\beta}_{1j}]$ and t-statistics. The most important output from this method are the maps formed by the municipalities' $\hat{\beta}_{1j}$ and their

t-statistics. These maps tell us how the parameters are changing in space, and where the estimates are positive, negative, or non-significant.

However, all the estimators from this method are biased, because we take samples of a changing stochastic process to estimate its parameters. Nevertheless, adopting the premise that the DGP does change in space, global regressions have a much stronger bias than local regressions. Therefore, the moving window regression is compelling enough to be explored.

This method poses a trade-off between bias and statistical power. As we increase the size of the parameter b, which controls the size of the local sample, we have a larger sample to use, increasing statistical power, but we also increase the area of estimation, which means we increase the risk of getting more bias when we use a single sample to estimate a more heterogeneous stochastic process.

GWR in more detail: Geographically Weighted Regression (GWR) is a weighted least squares regression with kernels based on geographical distance. The method was proposed by Fotheringham et al. (2002). GWR selects a point in space, not necessarily on an observed point, then attributes a kernel density in which less weight is given to distant points. GWR is used to capture local econometric relationships and spatial non-stationarity processes, and it is a case of a weighted least squares method. Hence if our model is $y = X\beta + u$, the GWR estimator is:

$$\hat{\beta} = (X'WX)^{-1}X'Wy$$

in the diagonal matrix W, we attribute to each observation a weight proportional to the distance.

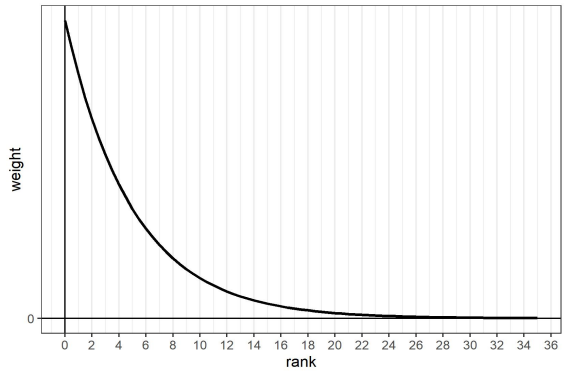
The first step to applying the GWR is to select some points on the map. In the present study, we use the centroids of municipalities. Note that we run a GWR, for each municipality of the sample. To calculate W we use an exponential function:

$$w_{ij} = \exp\left(\frac{-R_{ij}}{b}\right) \tag{4}$$

b is a tunning parameter if b is large the kernel is broader, and R_{ij} is the rank formed in the following way: i) for each municipality i we order the other municipalities in order of proximity; ii) for each we given an integer 0, 1, 2, 3, ... according to their order, those integers are the ranking R_{ij}; the focal municipality itself receives the rank of 0 (which is a weight of 1), the nearest neighbor receives 1, the second nearest neighbor receive 2 and so forth. The method applied here is a case of an *adaptive window*. The matrix W in GWR is not the same as the weight matrix used in spatial econometric models.

An *adaptive window* is preferred to a *fixed window*, when the distribution of observations in space is heterogeneous, which is our case. For example, in the North region of the country, the municipalities have bigger areas in relation to those in the Southeast region. Figure 3 reports the weights from Equation 4. The exponential kernel gives weights to all points in the map, but for sake of computer processing we limit the weights to 0.001, municipalities with weights with less than 0.001 are truncated to 0.

Figure 3: exponential function weights



3.2.1 Optimum b, Leave one out Cross-Validation

We use cross-validation and GWR to select the optimum size of b, i.e. the tunning parameter for the kernel size.

In the cross-validation method, the point that we want to predict is dropped from the sample, and then we run the regression. With the estimated results we predict the dropped observation, and we measure the error. Finally, we calculate for each k the following

$$CV_b = \sum_{i=1}^{5502} (y_i - \hat{y}_{\neq i})^2$$

where $\hat{y}_{\neq i}$ is the predicted value of the dropped observation (Fotheringham et al., 2002, p. 60).

We calculate CV_b for each value of b, and the lowest value of CV determines the optimum b.

To calculate $\hat{y}_{\neq i}$ we use GWR and as a consequence when we increase b, the values of estimated $\hat{\beta}$ change smoothly. Hence, when using GWR instead of least squares, for example, we have smoother graphs, and it is easier to determine the global minimum of the cross-validation loss function. After the cross-validation procedure we find that the optimal value is of b is 5. After determining the optimal b, and given that we chose a value to truncate in 0.001, the sample size of each GWR procedure is 35.

3.2.2 Family Wise Error Rate for GWR

Due to the problem of False Discovery Rate (FDR) we use a correction proposed by da Silva and Fotheringham (2015). The authors propose the following correction for the level of significance:

$$\alpha = \frac{\xi}{\frac{p_e}{p}} \tag{5}$$

where ξ is the family wise false discovery rate (we adopt a value of 0.01),

$$p_e = 2\text{tr}(S) - \text{tr}(S'S) \tag{6}$$

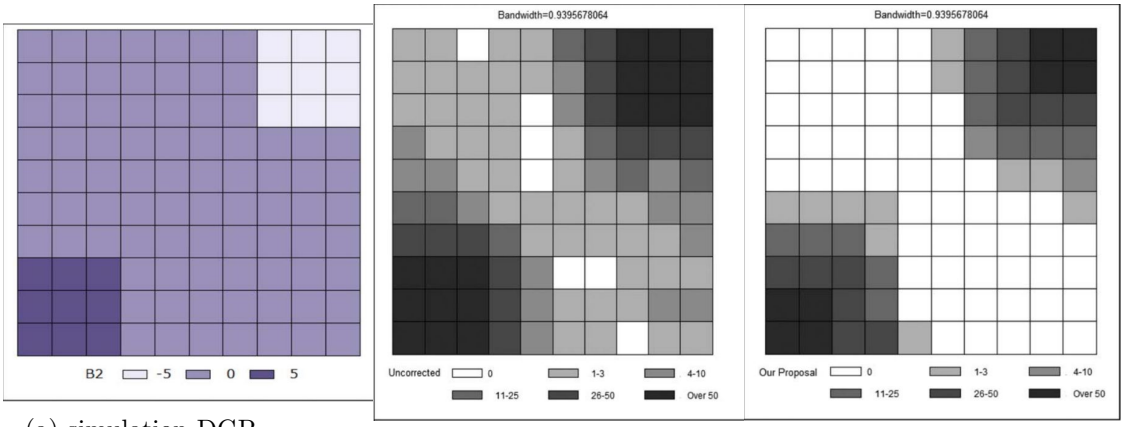
tr() means the trace of a matrix, and S is the hat matrix. We define $r_i = X_i(X'W_iX)^{-1}X'W_i$, where X_i is line i from matrix X. Hence $\hat{y}_i = r_i y_i$. Note that in our problem $k = 2$

(intercept and slope) and $n = 5502$, and X is $n \times k$ matrix; W_i are $n \times n$ matrices. Hence r_i is a line vector of length n. Each line of the matrix S is a r_i. The $\text{tr}(S)$ is a measure of dependency in the hypothesis tests.

In the context of GWR, da Silva and Fotheringham (2015) show that their family wise error rate measure is superior. Superior in terms of finding the correct rate of false discovery. They compare their false discovery rate correction to Benjamini–Hochberg False Discovery Rate (Benjamini and Hochberg, 1995) and from Byrne et al. (2009).

Figure 4 show simulations from da Silva and Fotheringham (2015) where panel (a) show the DGP, where in lower-left and upper-right corners the coefficients have values of 5 and -5. All the rest have null coefficient. Panel (b) show out of 100 simulations how many times we reject the null hypothesis of null coefficient, the ideal figure output should be similar to panel (a) the DGP. But we see that in many times the uncorrected t-test gives more false positives than it should be. And panel (c) shows the results of 100 simulations how many times the test from da Silva and Fotheringham (2015) rejects the null hypothesis. We note that in panel (c) the pattern is much closer to the DGP.

Figure 4: Simulation comparison of corrected and uncorrected t-test



(a) simulation DGP

(b) uncorrected t-test

(c) corrected t-test

Source: da Silva and Fotheringham (2015), pages 7 and 9

4 Data

4.1 IQIM

The measure of institutional quality in the present paper is the Municipal Insitutional Quality Index (IQIM - Índice de Qualidade Institucional Municipal) built by the Brazilian Ministry of Planning based on a dataset for the 5507 municipalities in 2000. The IQIM comprises information about municipal councils, financial capacity, and management capacity of the municipality, which are measures of local governance quality. All variables in the present study refer to the year 2000. Table 1 brings the components of the index (Ministry of Planning, 2001).[1]

[1] http://www.planejamento.gov.br/secretarias/upload/Arquivos/spi/downloads /081014_down_ex_pc_agen_relagenda.pdf/view

Table 1: IQIM components

Components	Variables	Weight
Civic Participation (33.3%)	number of councils	4%
	number of installed councils	4%
	number of councils with equal share	7%
	number of councils with veto power	7%
	number of councils that manage funds	11%
Financial Capacity (33.3%)	number of municipal partnership	11%
	debt	11%
	savings	11%
Management Capacity(33.3%)	IPTU last blueprint	8%
	IPTU default	8%
	number of management instruments	8%
	number of planning instruments	8%

4.1.1 Municipal Councils

The data that we use have information about the number of municipal councils that are established by law. But this does not mean that they are operational. So another variable is the number of councils that are *installed*, that is, which of them are working.

The sub-index of civic participation captures the level of civic engagement in the municipality: "Civic engagement refers to how citizens participate in the life of a community to improve conditions for others or to help shape the community's future" (Adler and Goggin, 2005). Municipal councils are an important form of civil society participation in the local political decision making. They are composed of representatives of the civil society and the municipal executive branch. The main responsibilities of the council are to propose public policies, supervise and deliberate on the public policies adopted in the municipality. For example, when the local government intends to build a new school or conduct a vaccination campaign. They also must approve the budget for the health system.

Municipal councils are created by municipal laws. Therefore, each municipality creates its councils, and they can be created by the civil society or by the government. The details of each municipal council are written in the legislature of each municipality. The municipal councils can act in many areas, and they have particularities. The Federal Constitution requires the existence of at least education, health, and social assistance municipal councils. However, there are many types of municipal councils as for the teenagers and children rights, senior citizen, citizen, women rights, social assistance, culture, alcohol and drugs abuse, environmental rights, animal rights, and so on.

Some councils can manage funds and apply the resources of the government. For example, the Federal Government or the State Government transfers resources for education. In this case, the municipal council for education can manage the funds and choose in which projects they are going to be spent or maintaining which programs. Some municipal councils are said to be *deliberative* in the sense that they discuss some public policy or political decision, but they do not have the power to veto or hinder the

execution of a project or policy making. The councils that can impede the execution of projects of the municipal government or the budget spending are those with *veto power*. Councils *with an equal share of chairs* are those composed of members of the municipal government and of the civil society in the same proportion, giving more capacity of action by the civil society.

Although the municipal council can be a source of improvement of the population's welfare, there are flaws in them. The disclosure of information about the decision making and budget of each municipality depends on the internal regulation of each council. In many instances, there are no guidelines to the regular publication of information about the decision and what is discussed. Rizotti et al. (1999) in a study of the municipal councils in the west of the Paraná state found that in some instances the majority of representatives of the civil society that compose the councils are firms that supply the goods and services for social assistance. In this situation, the councils will tend to act in the interests of the firms and not of the population.

It is important to make a distinction between civil society and other institutions. The civil society is composed of families and private interests. A better civic society or civic engagement is characterized by better informed and aware citizens who make better voting choices, participate more in politics and are more propense to hold governments accountable. Putnam (1993) argues that not only political institutions in the strict sense are vital for democracy, but other types of institutions are important as well. Municipal councils are institutions in which civil society can have greater access to local political decision making, improving the quality of the political institutions.

4.1.2 Local Governance

Local Governance is the process from the interaction between the local government and the civil society with the intent to achieve its objectives (Ckagnazaroff, 2009). The Financial and Management Capacity indicators of the IQIM capture important aspects of local governance. The Financial Capacity indicator is composed of the number of local partnerships, municipal debt in relation to tax income, and per capita savings of the local government. The municipal government can make partnerships with other municipalities, the state government, and the federal government to construct new buildings and roads, for instance. A type of municipal partnership in the public health system occurs when a municipality's hospital attends patients of its municipal neighbors.

The municipality government's debt in relation to its tax revenue measures the municipality's indebtedness and financial management capacity. The savings indicator is the municipal government savings divided by its population. A higher ratio signs better financial capacity of the municipality.

The municipal Management Capacity Indicator is composed of the last update of the real estate values for property tax (IPTU) collection and its default rate, and the number of management and planning instruments. When the last update of the property values for IPTU collection is outdated and its default rate is high, the municipal government has a low management capacity. The *number of management instruments* is related to the number of municipal laws related to local administration, i.e., if there are any intra-municipality administrative system or administrative division, the existence of zoning law dividing land areas destined to industrial or residential buildings, for instance. The *number of planning instruments* evaluates if the municipality has a government plan, strategic plan, or organic law, which determines the course of municipal government actions.

Overall, the IQIM index captures the institutional political quality in the municipality.

It does not measure the same political institutions circumscribed in Acemoglu and Robinson (2012), but the IQIM captures the essence of population participation in the municipal public decisions and local government capacity, which are related to more inclusive political institutions.

4.2 Summary Statistics

Table 2 reports descriptive data statistics for year 2000. GDP per capita (log scale) is from IBGE for the year 2000, IDHM (Índice de Desenvolvimento Humano Municipal) is the Municipal Human Development Index, Gini is the inequality index, Education is the expected years of schooling in the municipality. The last three variables are from the Brazilian Human Development Atlas 3.

The human development index, education, economic inequality, and GDP per capita are all variables that we use to represent economic development. The IDHM is an adapted index from the methodology of countries HDI. IDHM is a geometric mean of three indexes: IDHM Health, IDHM Education, and IDHM Income. The latter contains information about GDP per capita. IDHM Health contains information about the life expectancy at birth in each municipality. IDHM Education is a weighted geometric mean of adult population schooling and percentage of school attendance. The Gini index measures the household income inequality, and smaller values in the municipality mean less inequality.

Table 2: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.
Distance to Portugal	7.73	1.035	5.99	9.93
Gold	0.123	0.281	0	1
Sugar	0.075	0.202	0	1
IQIM	3.026	0.552	1.0	4.9
Instrumentalized IQIM	3.026	0.320	2.477	3.716
GDP	1.108	0.715	-0.444	4.817
IDHM	0.523	0.104	0.214	0.820
GINI	0.547	0.068	0.30	0.87
Education	8.336	1.795	2.29	13.02

"GDP" of each municipality data is gathered from IBGE for the year 2000 (GDP per capita is in log scale, so that the distribution is more symmetric). "IDHM" is the Municipal Human Development Index. Including this variable and downwards all variables are from the Human Development Atlas for Brazil, further explained in more detail. "GINI" is the inequality index, the lower the index more economically equal is the municipality. "Education" is expected years of schooling in the municipality.

4.3 Missing Values

In the dataset, there are some missings. We drop the municipalities that are islands because we could not have non-singular neighboring matrices. We also drop all municipalities that have no information about the IQIM, and we end up with a sample of 5502 municipalities. To include values for missing data, we interpolate using the IDW interpolation method (inverse distance weighting):

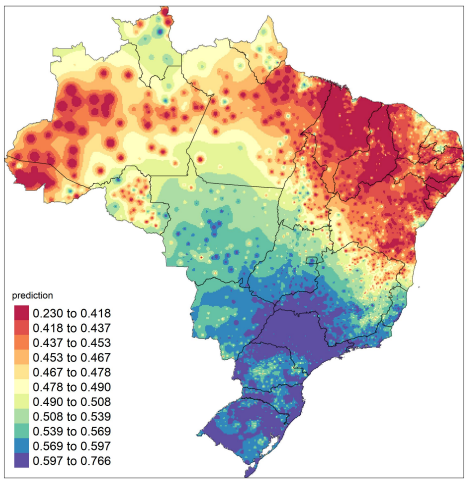
$$Z(s_0) = \frac{\sum_{i=1}^{n} w(s_i) Z(s_i)}{\sum_{i=1}^{n} w(s_i)}$$

where $w(s_i) = ||s_i - s_0||^{-p}$; s_i is the location of the municipality i and $Z(s_i)$ is the value of the variable in location i. s_0 is the point to be interpolated, and we considered $p = 1$, so we use a simple Euclidean distance. This method uses the information of all points available. One of the characteristics of the IDW interpolation method is that the value $Z(s_0)$ will never remain outside the range of observed values (Bivand et al., 2013). Hence, the interpolated values are bounded to the original sample range values.

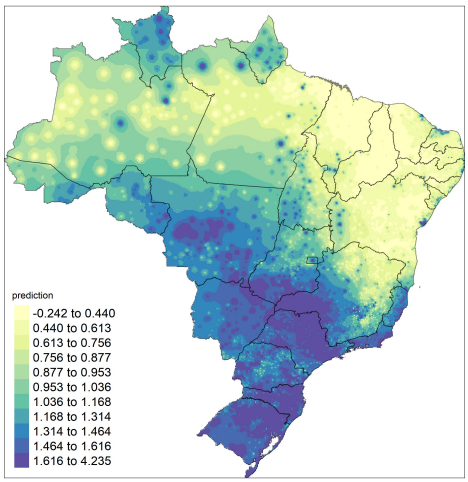
4.4 Maps of the Data

Figure 5 brings maps of the explained variables. For IDHM, ln GDP per capita and education, there is a clear south-north differentiation. In the Gini index, we note that the South of Brazil is more egalitarian.

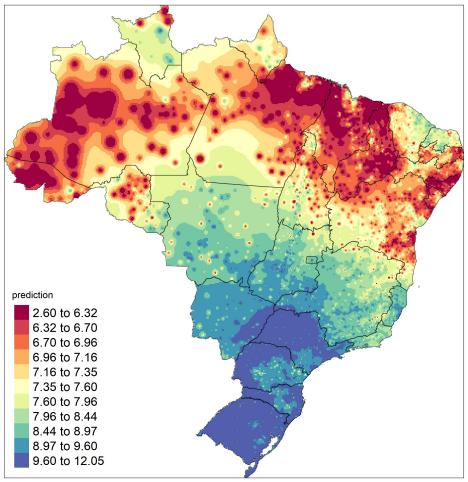
Figure 5: Maps of Variables



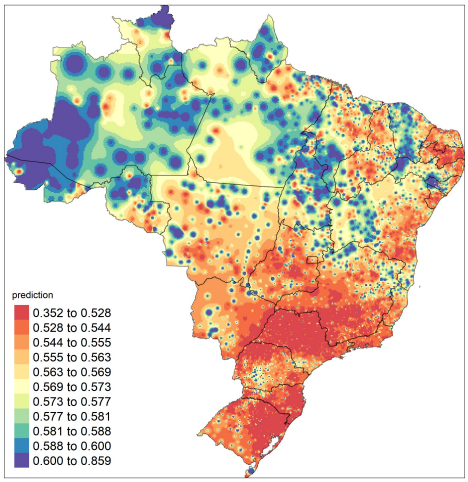
(a) IDHM



(b) log GDP per capita



(c) Education



(d) GINI

5 Empirical Results

5.1 First-Stage

Table 3 presents the first-stage results. The presence of the gold cycle and distance to Portugal have the expected sign, and they have significant impacts in columns (1) and (2). In column (1), the presence of the sugar cycle is not significant, but in column (2) it is significant and positive. The interaction between gold and distance to Portugal is positive and significant, as expected. Column (3) does not use the Distance to Portugal as an instrument. The coefficients for the sugar and gold cycles are significant and have the expected sign, but this specification has a lower F-statistic. We use the specification of column (1) to calculate the instrumentalized IQIM since it is the same specification used by Naritomi et al. (2012).

Table 3: First-Stage

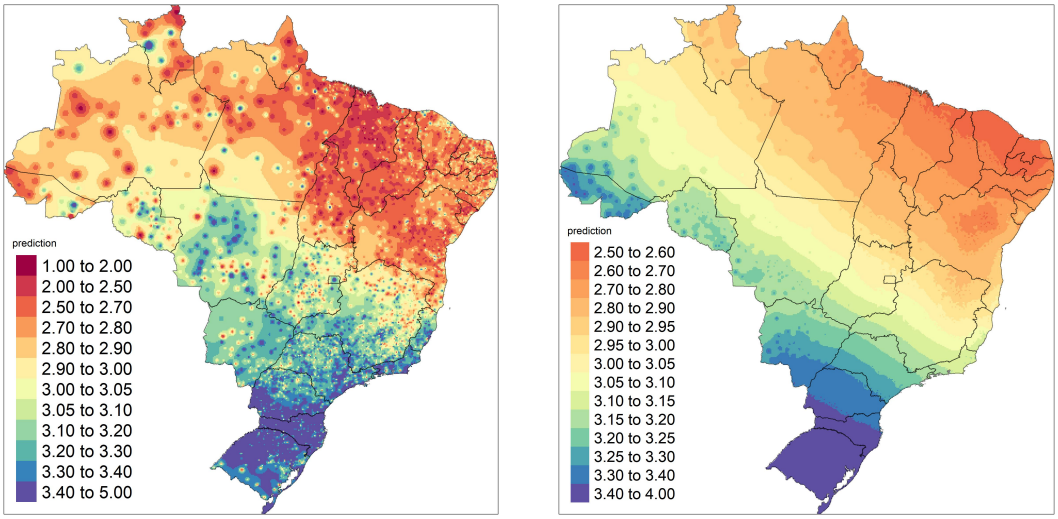
	(1)	(2)	(3)
Explanatory	Dependent Variable:		
Variables	**IQIM**		
Distance to Portugal (DP)	0.318***	0.320***	
	(0.007)	(0.006)	
Gold	-1.347***	-0.048***	-0.103***
	(0.391)	(0.022)	(0.027)
Sugar	0.516	0.180***	-0.432***
	(0.386)	(0.033)	(0.037)
Gold · DP	0.168***		
	(0.051)		
Sugar · DP	-0.050		
	(0.057)		
Intercept	0.561***	0.547***	3.072***
	(0.052)	(0.050)	(0.009)
Method	OLS	OLS	OLS
Observation	5502	5502	5502
F-statistic	557.5	923.5	73.6

Notes: ***, **, * means p-value < 0.01, 0.05, 0.10.
Standard deviations are in parenthesis.

Figure 6 reports the original and instrumentalized IQIM. In the figure with the instrumentalized IQIM, we can notice the gradient of distances to Portugal. Therefore, it is mostly determined by distance from Portugal. Note that the two maps have different palette colors. Instead of distance from Portugal, the ideal variable would be time or cost of transport and communication between a certain region of Brazil and Portugal during the two cycles time. This variable would capture better the influence of the Metropole on the colonial region. However, this variable is not available, and it would be hard to measure, so as a proxy, we use distance from Portugal.

Distance from Portugal acts similarly to latitude, because Portugal is located in the northeast direction from Brazil, and the equator line is situated in the north of Brazil. The south is, in general, institutionally better than the north. This may be the reason why latitude works well as an instrument for institutional quality in previous studies, as Nakabashi et al. (2013).

Figure 6: IQIM and Instrumentalized IQIM



(a) Original IQIM (b) Instrumentalized IQIM

5.2 Global Results

Table 4 shows the global regression results for the variables capturing economic development. All the estimated coefficients have the expected signs and are significant. Global regressions show that increasing institutional quality decrease inequality and increase GDP per capita, IDHM, and Education. Therefore, in a global analysis, institutions increase the economic development of the Brazilian regions.

Table 4: Global Regressions

	(1)	(2)	(3)	(4)
Explanatory		Dependent Variable:		
Variables	IDHM	GDP per capita	Education	GINI
Instrumentalized IQIM	0.238	1.572	3.965	-0.0522
	(0.003)	(0.021)	(0.053)	(0.0028)
Intercept	-0.196	-3.648	-3.662	0.705
	(0.009)	(0.065)	(0.162)	(0.008)
Method	2SLS	2SLS	2SLS	2SLS
Observation	5502	5502	5502	5502

Notes: Standard deviations are in parenthesis. All estimates are significant at 1% significance level.

5.3 Empirical Results from GWR

Figure 7 reports the estimates of GWR regressions method. In panel (c), red is for negative and significant estimated coefficients, and green is for positive and significant effects (10% significance level). White areas are non-significant areas. In panel (c), we see that the positive and negative estimated coefficients are not distributed in a clear pattern across the country, that is, the green and red spots are mixed in all regions.

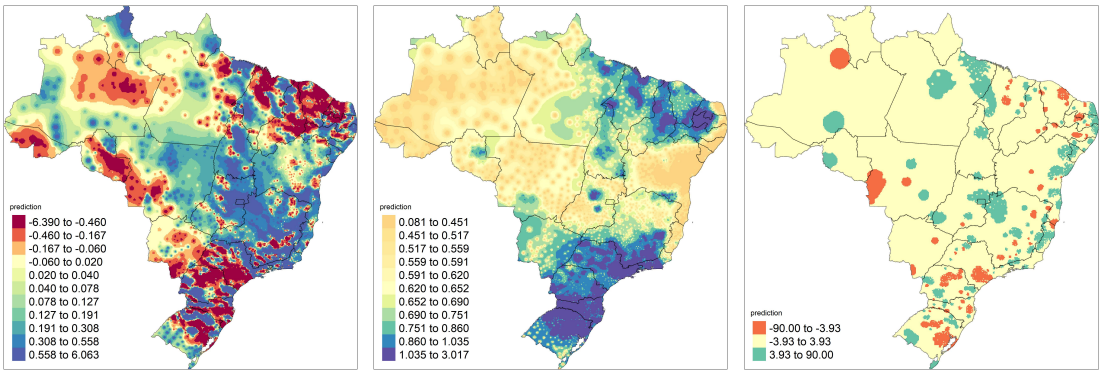
The t-statistics values in panel (c) were chosen using the correction for the family-wise error rate from da Silva and Fotheringham (2015). We find that the parameter $p_e = 492.24$, and $p = 2$ hence $\alpha = \frac{0.10}{\frac{492.24}{2}} = 0.0001015765$ (see equation 5), which gives for

t distribution with 33 degrees of freedom the value of 3.93, this is the corrected critical value for a 10% false discovery rate. Note that the value of p_e (see equation 6) only depends on the covariates matrix X and weights matrix W which is determined by the weighting function and GWR points being evaluated.

It is important to give a caveat: in panel (c) (and all t-statistics maps henceforth) we expanded around the regions of significance so that we can better compare and see in which place the significance took place. Otherwise, we would only see a few scattered points in the map which would not be informative. A true indicator of the proportion of significant points is given in table 5.

Panel (a) shows how heterogeneous the parameter $\hat{\beta}_1$ is in space. The institutional quality affects IDHM is positive and negative ways in all regions of Brazil. There are municipalities in all regions where the institutional effects are not statistically significant probably because the samples are composed of similar municipalities, and the instrumentalization procedure has smoothed the IQIM values in the neighboring municipalities. And the importance of institutions and economic development holds when comparing more different municipalities, i.e., those in the South and Southeast of Brazil in relation to those in the North and Northeast of the country. Besides, the gold and sugar cycles influenced the formation of the initial institutions in only part of the Brazilian municipalities. Anyhow, the results indicate that institutional quality does not increase economic development in all regions of the country, as the results of the global regression suggest.

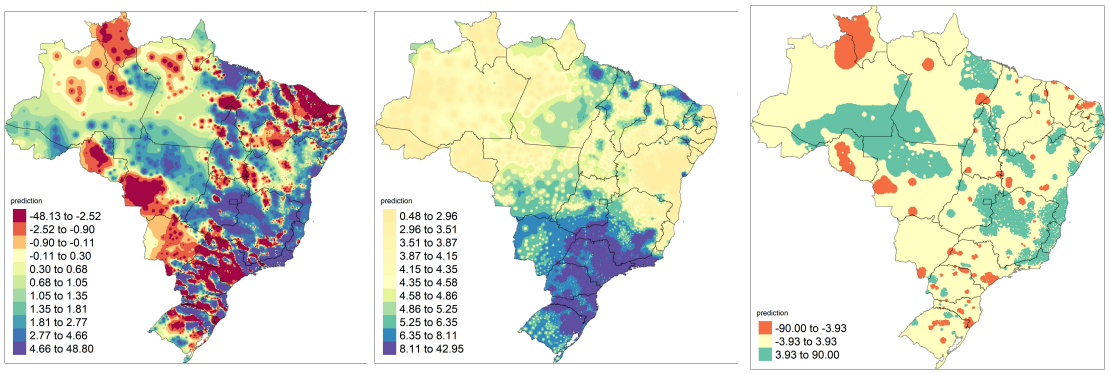
Figure 7: β_1 estimates GWR, IDHM - Instrumentalized IQIM.



(a) Coefficients (b) standard deviation (c) t-statistics

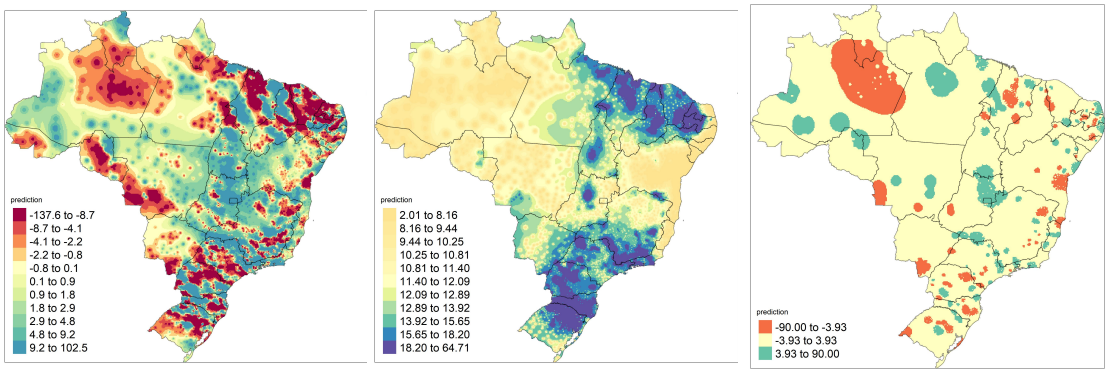
Figures 8 and 9 show the maps of GWR for GDP per capita and the educational measure as the explained variables. Both figures show a similar pattern to Figure 7 in the sense that roughly the same regions that are green happen in the same places in those maps. Compared to the other figures, Figure 8 show larger areas for the significant spots. This may be misleading given that we artificially expanded the significant areas for visualization purposes. But this expansion can roughly show in which parts of Brazil positive and negative coefficients appear.

Figure 8: β_1 estimates GWR, GDP per capita - Instrumentalized IQIM.



(a) Coefficients (b) standard deviation (c) t-statistics

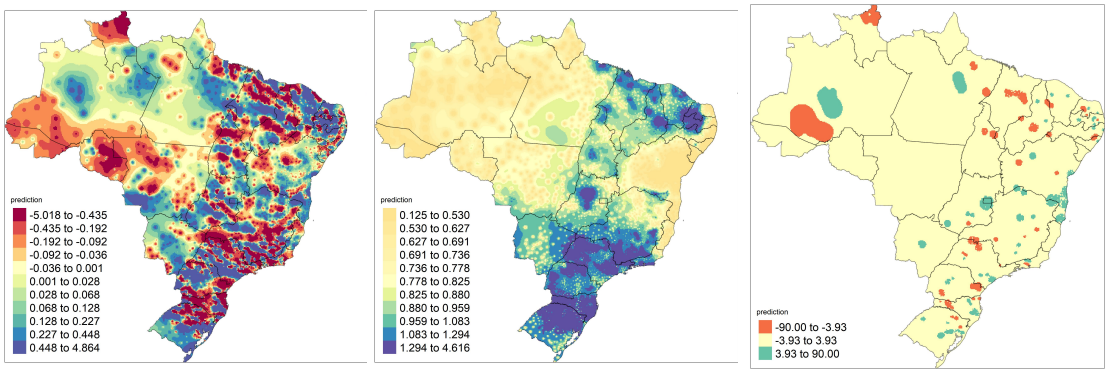
Figure 9: β_1 estimates GWR, Education - Instrumentalized IQIM.



(a) Coefficients (b) standard deviation (c) t-statistics

Figure 10 reports the GWR for the Gini index as the explained variable. Note that negative coefficients are what we expect because a lower Gini means less inequality.

Figure 10: β_1 estimates GWR, GINI - Instrumentalized IQIM.



(a) Coefficients (b) standard deviation (c) t-statistics

Table 5 shows the proportion of municipalities in each state in which the coefficients

fall into the positive or negative significant category. We use 10% significance level. Note that the proportion in Brazil for IDHM shows that positive significant cases appear slightly more than negative significant cases (0.0458, 0.0302). This happens with GDP and Educ. In the case of GINI for Brazil, the positive coefficient (unexpected case) appears slightly more (0.0156, 0.0144).

The low proportion of significant coefficient occurs for some reasons: i) family-wise error rate correction significantly increases the t critical value. ii) the local sample is small, size 35; and in this small sample the variance of X is small (given that the municipalities are similar to each other, X does not change much in each sample) which gives a high variance for $\hat{\beta}$; iii) the large variance of $\hat{\beta}$ is further amplified by the IV procedure, given that IQIM is smoothed with the instrumentalization procedure.

Table 5: Proportion of positive, negative and non significant $\hat{\beta}_1$ of IDHM

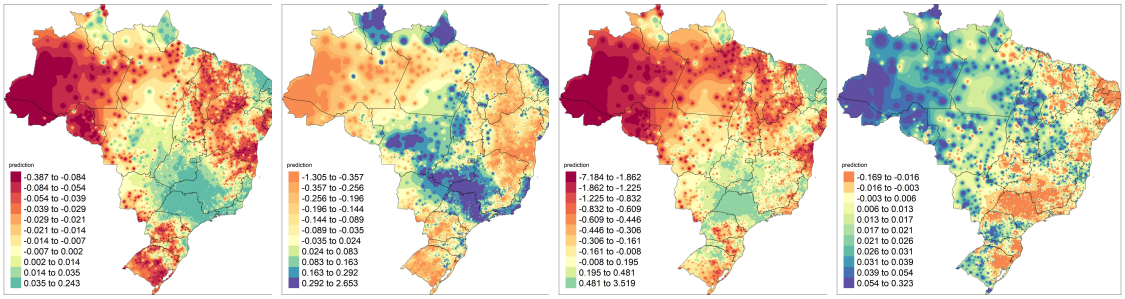
	IDHM		GDP		Educ		GINI	
	t > 3.93	t < −3.93	t > 3.93	t < −3.93	t > 3.93	t < −3.93	t > 3.93	t < −3.93
Brasil	0.0458	0.0302	0.0509	0.0256	0.0364	0.0322	0.0156	0.0144
Center-West	0.0293	0.0203	0.0698	0.0248	0.0293	0.0270	0.0203	0.0023
North	0.0445	0.0022	0.0735	0.0379	0.0490	0.0334	0.0089	0.0200
Northeast	0.0571	0.0291	0.0487	0.0202	0.0414	0.0420	0.0185	0.0157
South	0.0431	0.0526	0.0276	0.0397	0.0302	0.0449	0.0164	0.0190
Southeast	0.0403	0.0258	0.0583	0.0186	0.0337	0.0138	0.0126	0.0114
AC	0.0000	0.0000	0.0455	0.0000	0.0000	0.0000	0.0000	0.0000
AL	0.0792	0.0000	0.0693	0.0099	0.0099	0.0198	0.0198	0.0396
AM	0.0161	0.0161	0.0806	0.0161	0.0484	0.1774	0.0323	0.0484
AP	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BA	0.0627	0.0169	0.0771	0.0145	0.0337	0.0602	0.0361	0.0048
CE	0.0109	0.0543	0.0000	0.0272	0.0380	0.0163	0.0109	0.0054
DF	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000
ES	0.1039	0.0260	0.1169	0.0000	0.0649	0.0260	0.0000	0.0000
GO	0.0415	0.0041	0.0830	0.0083	0.0332	0.0083	0.0290	0.0041
MA	0.0369	0.0323	0.0184	0.0138	0.0553	0.0737	0.0000	0.0276
MG	0.0516	0.0234	0.0868	0.0094	0.0317	0.0129	0.0129	0.0082
MS	0.0000	0.0395	0.0000	0.0526	0.0132	0.0789	0.0132	0.0000
MT	0.0159	0.0397	0.0794	0.0397	0.0238	0.0317	0.0000	0.0000
PA	0.0979	0.0000	0.0979	0.0280	0.0699	0.0000	0.0140	0.0140
PB	0.0762	0.0314	0.0762	0.0090	0.0583	0.0628	0.0314	0.0090
PE	0.0761	0.0489	0.0598	0.0000	0.0707	0.0380	0.0163	0.0217
PI	0.0136	0.0136	0.0271	0.0226	0.0045	0.0090	0.0090	0.0226
PR	0.0602	0.0501	0.0426	0.0426	0.0326	0.0501	0.0075	0.0226
RJ	0.0549	0.0000	0.0879	0.0000	0.0879	0.0000	0.0330	0.0330
RN	0.1145	0.0542	0.0542	0.0843	0.0783	0.0301	0.0120	0.0241
RO	0.0192	0.0000	0.0385	0.0769	0.0385	0.0000	0.0000	0.0000
RR	0.0000	0.0000	0.0000	0.2667	0.0000	0.0667	0.0000	0.1333
RS	0.0385	0.0600	0.0257	0.0257	0.0300	0.0450	0.0214	0.0086
SC	0.0273	0.0444	0.0102	0.0580	0.0273	0.0375	0.0205	0.0307
SE	0.0667	0.0000	0.0133	0.0000	0.0000	0.0133	0.0000	0.0000
SP	0.0156	0.0327	0.0093	0.0358	0.0249	0.0156	0.0109	0.0140
TO	0.0288	0.0000	0.0791	0.0288	0.0504	0.0216	0.0000	0.0144

5.4 Global and Local Residuals

Figure 11 shows the residuals of global regressions for the specifications where IDHM, GDP per capita, education, and the Gini index are the explanatory variables. There are noticeable clusters of high and low values across the Brazilian regions. It is a pattern that the global model usually under-predicts the explained variables in some regions of

São Paulo, Minas Gerais, and some parts of Ceará and Rio Grande do Norte. The same pattern occurs with the Gini index, but with the opposite sign because lower Gini values mean less inequality.

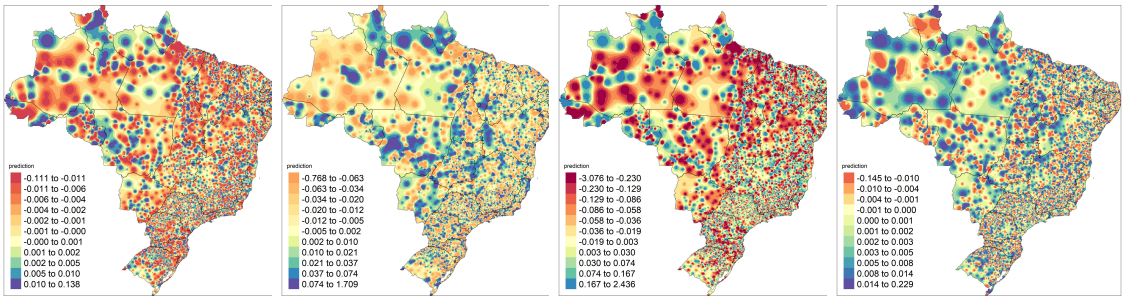
Figure 11: Residuals of Global Regressions



(a) IDHM (b) GDP pc (c) Education (d) GINI

Figure 12 shows the residuals from the regressions via the moving window GWR method. There are no clear patterns or clusters of high and low values of the residuals. Therefore, the data is better adjusted when using the local regression method, with a great reduction in the degree of the residuals spatial correlation. For each local sample we use only the central municipality to calculate the residuals that goes in the map. Hence, for each municipality there is only one residual.

Figure 12: Residuals of Local GWR Regression



(a) IDHM (b) GDP pc (c) Education (d) GINI

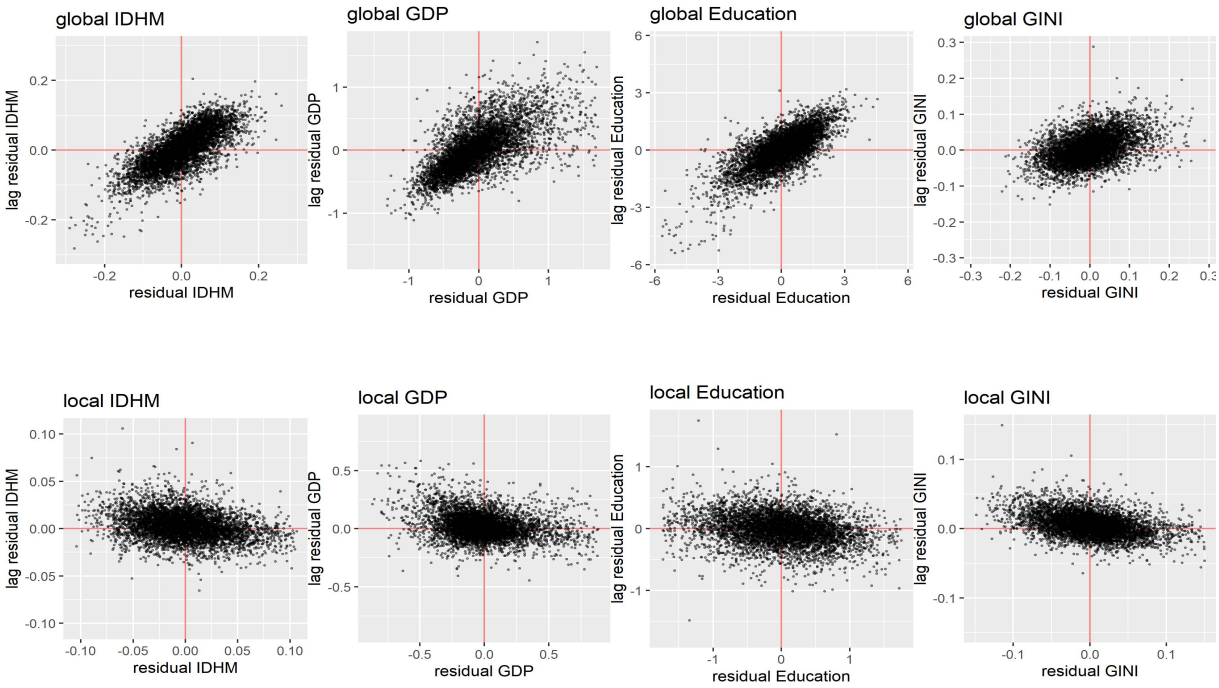
The p-values of the Moran's I tests for residual of the four global regressions are close to 0 while for all four Moran's I tests for the residual of the local GWR regressions the p-values are close to 1. Therefore there is no remaining spatial correlation in the residuals of the local GWR regressions. Table 6 show the Moran's I statistic for the regressions.

Table 6: Moran's I estimate for residuals of global and local regressions

	IDHM	GDP	Education	GINI
Global	0.595	0.472	0.587	0.267
Local	-0.113	-0.112	-0.093	-0.143

Figure 13 reports the scatterplots of the residuals against their spatial lag, using the municipality's territory as the criterion to build the spatial-neighbors matrix.

Figure 13: Scatter plots residuals and spatial lag, global and local



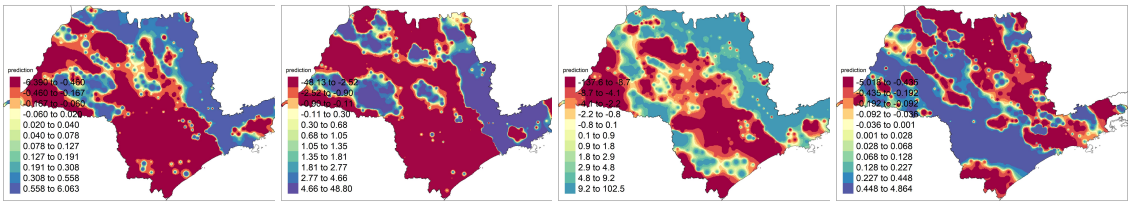
5.5 Local GWR maps and graphs

Figures 14, 15 and 16 report the estimates of $\hat{\beta}_1$ of the moving window GWR method for the states of São Paulo, Minas Gerais and Bahia. IDHM, GDP per capita and education have the same spatial pattern in all three states, with high and low values in the same locations. The Gini index, on the other hand, has the opposite pattern in most regions, as expected. The Gini index seems more related to the educational level than to IDHM or GDP per capita.

We choose those three states because São Paulo does not have influence of Gold nor Sugar cycles. Bahia have influence of both cycles and Minas Gerais have influence of only Gold cycle. Besides, those are economically important and populated states.

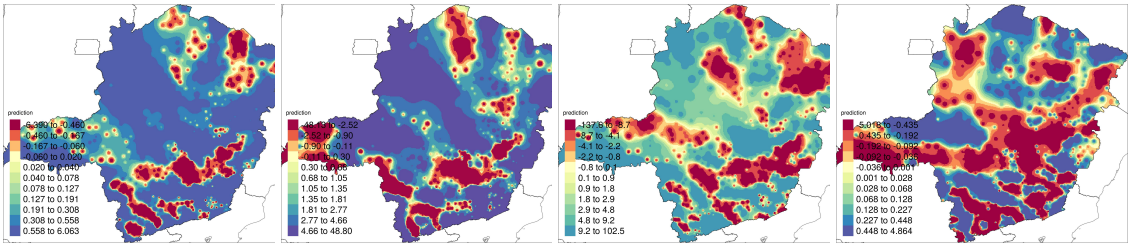
Note that in the case of São Paulo, some red areas (which in the case of Gini is good) on the north of the state are the same locations where there are blue areas for the IDHM variable. The contrast also appears in the other two states but to a lesser extent.

Figure 14: GWR estimates for the state of São Paulo



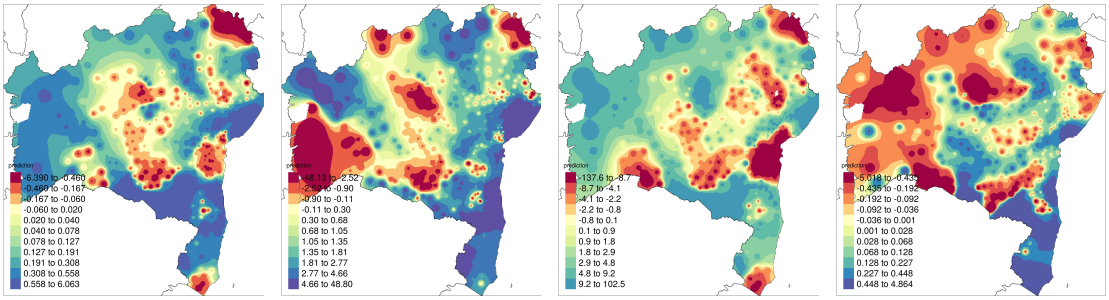
(a) IDHM (b) GDP pc (c) Education (d) GINI

Figure 15: GWR estimates for the state of Minas Gerais



(a) IDHM (b) GDP pc (c) Education (d) GINI

Figure 16: GWR estimates for the state of Bahia



(a) IDHM (b) GDP pc (c) Education (d) GINI

6 Concluding Remarks

We find that the results of the Global Regressions present the expected sign and significance when measuring the effects of institutional quality on economic development measures. The results indicate that inclusive political institutions increase standards of living through higher IDHM, GDP per capita, education, and less income inequality. On the other hand, the estimates for local GWR regressions do not always show that the effects of political institutions on economic development are positive. Besides, there are municipalities in all regions where the institutional effects are not statistically

significant probably because the samples are composed of similar municipalities, and the instrumentalization procedure has smoothed the IQIM values in the neighboring municipalities. In addition, the gold and sugar cycles influenced the formation of the initial institutions in only part of the Brazilian municipalities. It is important to highlight that the set of instruments used in the first-stage can significantly impact the map patterns and the estimates layout, the proportion of positive, non-significant, and negative municipalities. That is, if we change the instruments in the first stage, the estimated coefficients and standard deviation maps will change. Simpson's Paradox is also a potential explanation for the divergent results.

The proportion of municipalities with positive, negative, and non-significant estimated coefficients is between ... and ... in the Brazilian regions.

Figures 11 and 12 report the global and local residuals, and below them are the scatterplots of residuals and spatially lagged residuals. The local residuals show much less spatial correlation and clustering than global residuals, and the Moran's I statistic show no spatial correlation for local residuals, favoring the local regression method.

The use of local regression methodology opens new insights concerning the relationship between institutional quality and economic development in Brazil as our results indicate that the institutional quality may not always promote economic development. In future studies, it is important to take into consideration the influence of the instrumentalization procedure and to analyze the effects of sample size in the results since the comparison of different regions may be the explanation of the discrepancy between local and global regression results. In other words, the local regression compares municipalities that are close in their geographical distance, and they are more similar in many aspects, reducing, eliminating or even inverting the importance of institutions in the explanation of economic development in the Brazilian municipalities. The similarity in the institutional measure across municipalities in the same sample can be even higher with the instrumentalization procedure.

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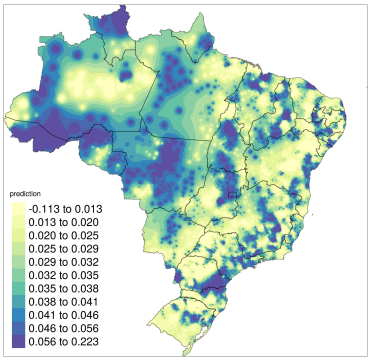
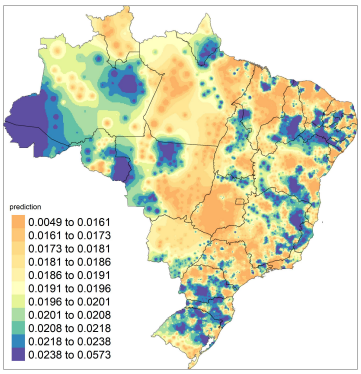
A Correlation

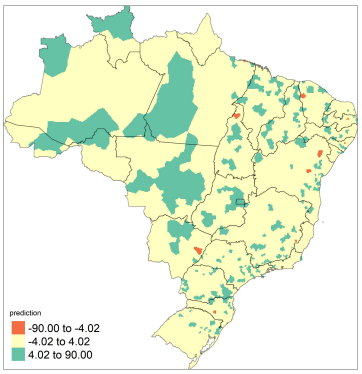
Figure 17: Non-instrumentalized GWR



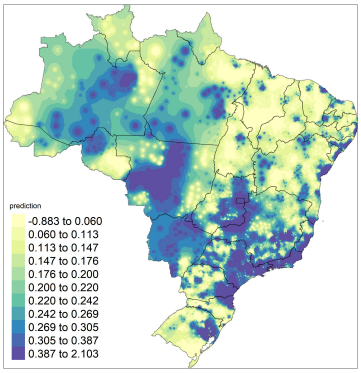
(a) IDHM coefficient



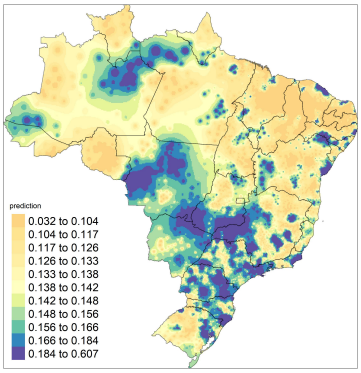
(b) IDHM sd



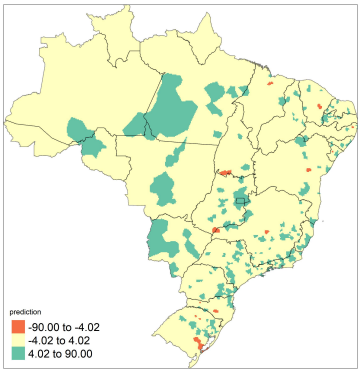
(b) IDHM t



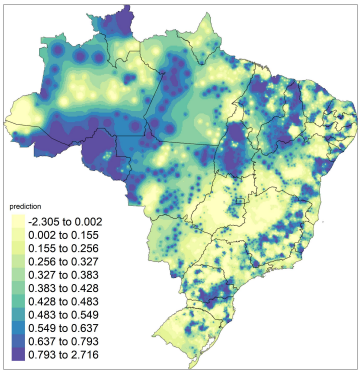
(a) GDPpc coefficient



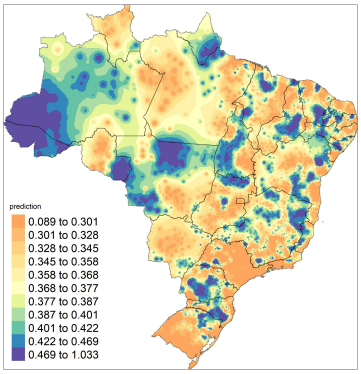
(b) GDPpc sd



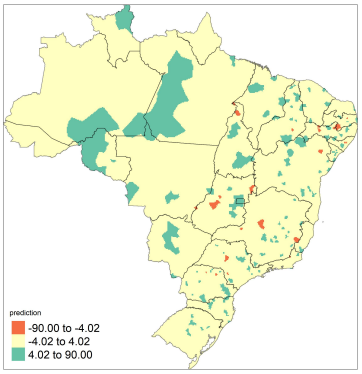
(b) GDPpc t



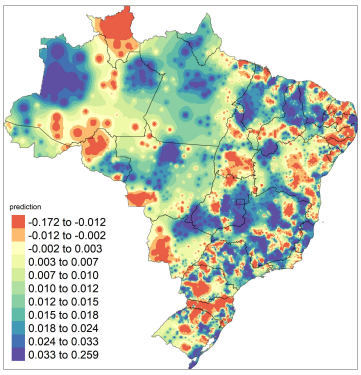
(a) Educ coefficient



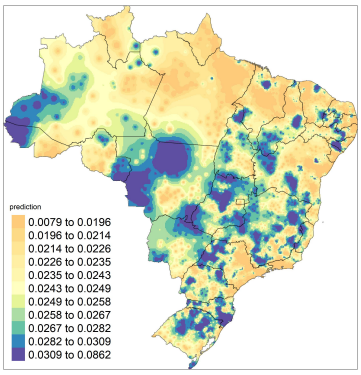
(b) Educ sd



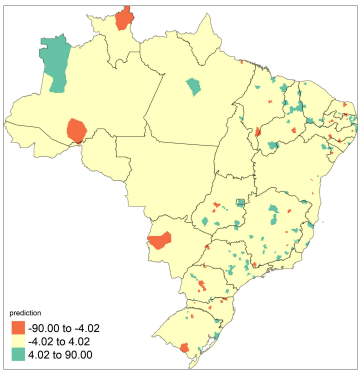
(b) Educ t



(a) GINI coefficient



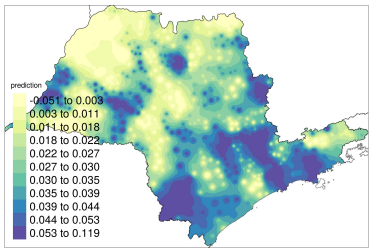
(b) GINI sd



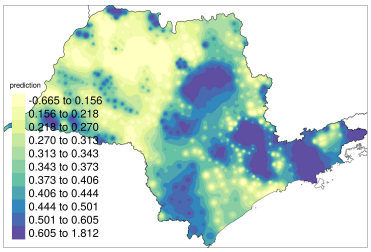
(b) GINI t

B Local Maps and Comparisons

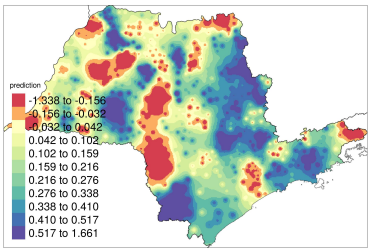
Figure 18: Non-instrumentalized GWR Local Maps



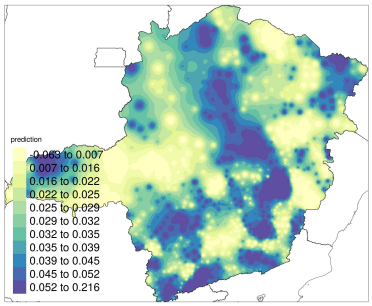
(a) IDHM SP



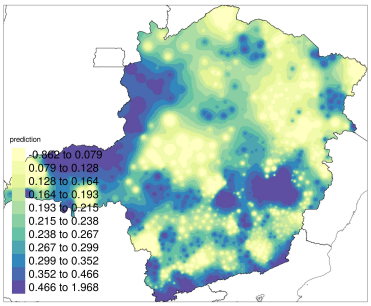
(b) GDP SP



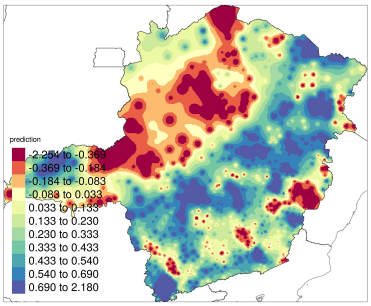
(b) Educ SP



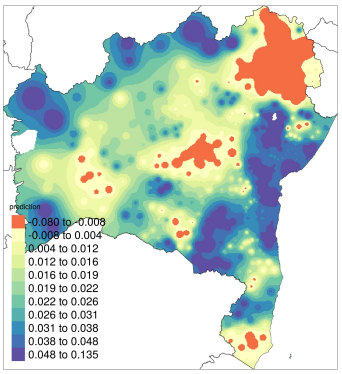
(a) IDHM MG



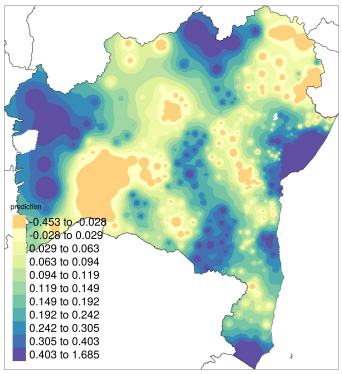
(b) GDP MG



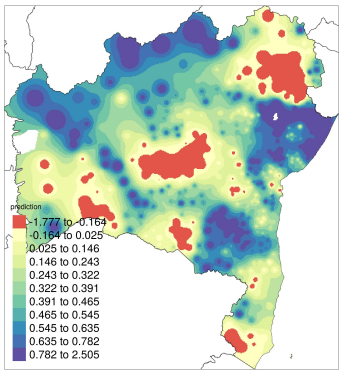
(b) Educ MG



(a) IDHM BA



(b) GDP BA

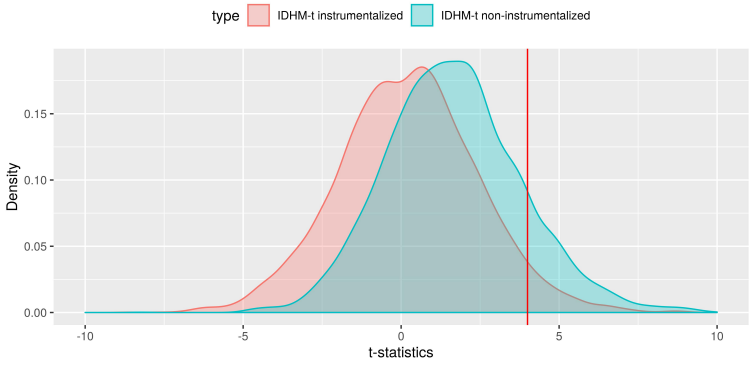


(b) Educ BA

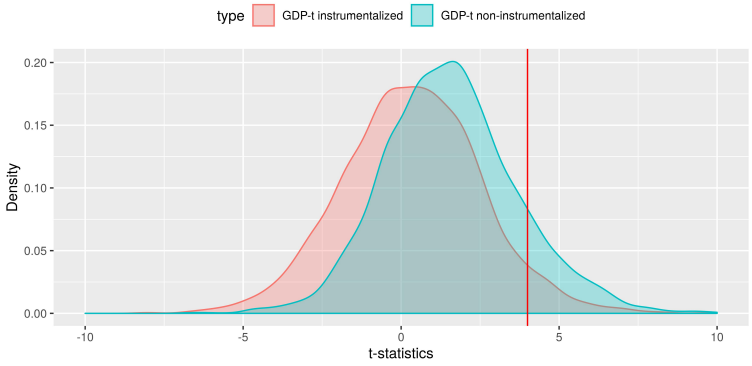
Figure 18 show for the states of São Paulo, Minas Gerais and Bahia the estimates of non-instrumentalized GWR.

In Figure 18 blue values are positive $\hat{\beta}_1$. Yellow are values close to zero. For IDHM and GDP almost in all places, the values are positive or close to zero. In Bahia, there are some orange spots that are negative. For Education for all three states, there are some red spots. Red spots are negative values.

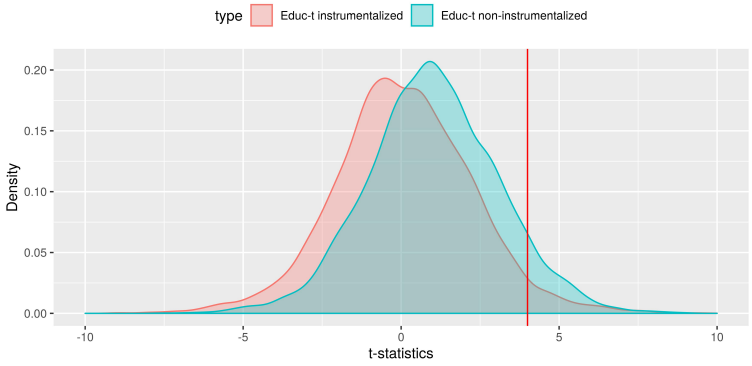
Figure 19: Density instrumentalized and non-instrumentalized t-statisics



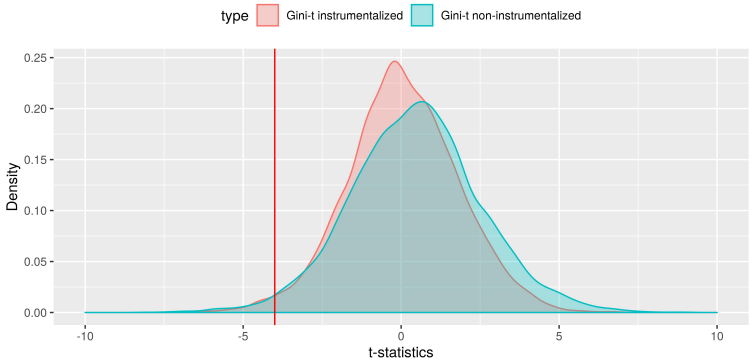
IDHM



GDP



Educ



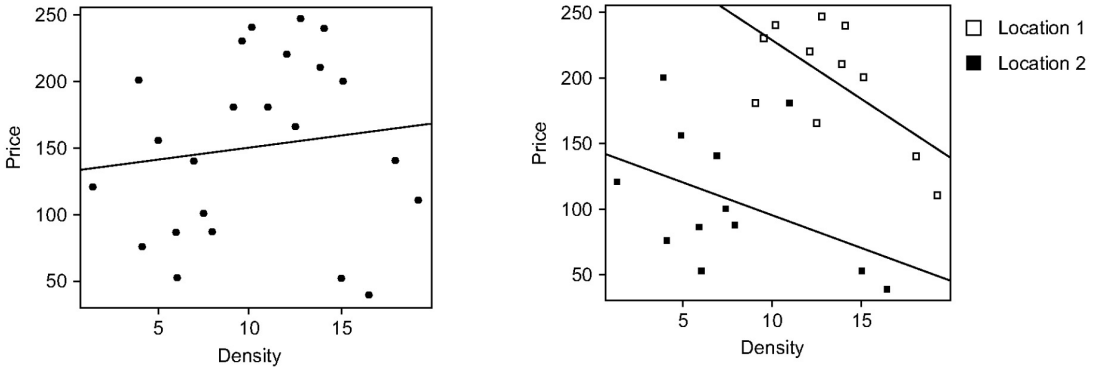
GINI

In Figure 19 note how on non-instrumentalized regressions, $\hat{\beta}_1$ tends to be positive more times and be statistically positive more times too. The red line has the value of 4 which is approximately the significance level for corrected FDR.

C Simpson's Paradox

Figure 20 presented in Fotheringham et al. (2002)[p. 8] show the phenomenon called Simpson's Paradox. In some estimations, global aggregate analysis shows a positive relationship between variables (panel a.), but the local analysis can show the opposite, i.e., a negative relationship between the variables (panel b.). Simpson's paradox in the present study is a possible explanation of the differences found in the results of the local and global regression.

Figure 20: Simpson's Paradox



(a) Spatially aggregated data (b) Spatially disagregated data

Source: Fotheringham et al. (2002) section 1.3, page 8